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Model E-120/E-120E

Geiger Counter

E-120/E-120E Geiger Counter
Technical Manual

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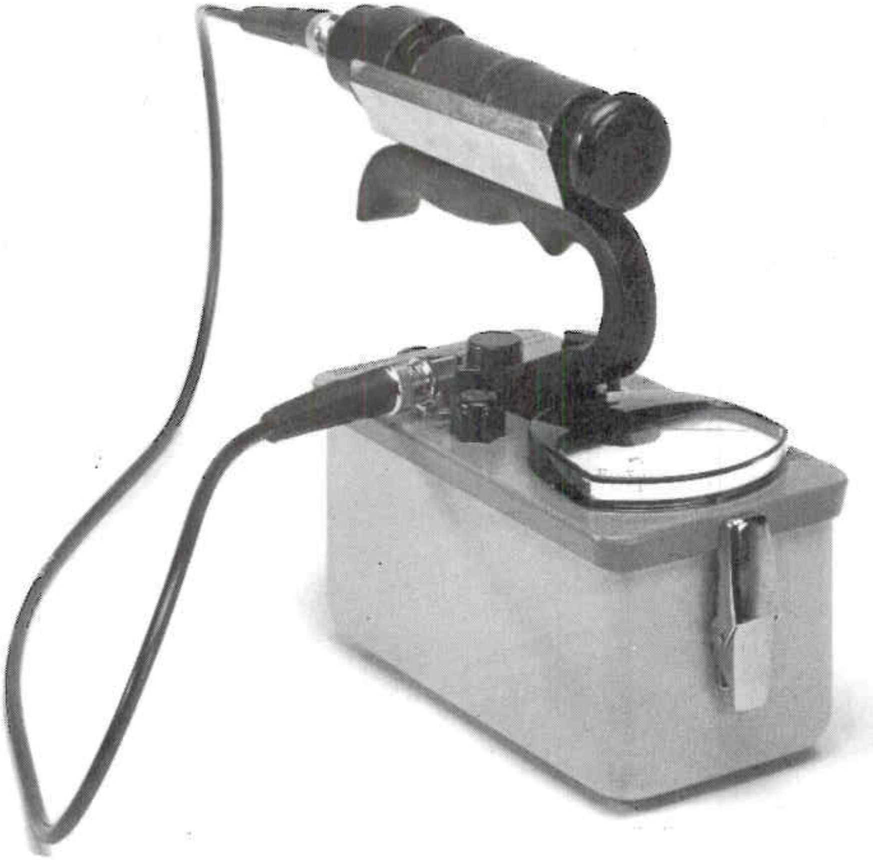

Figure 1-1. E-120 Shown with HP-270 Probe and CA-1 Cord

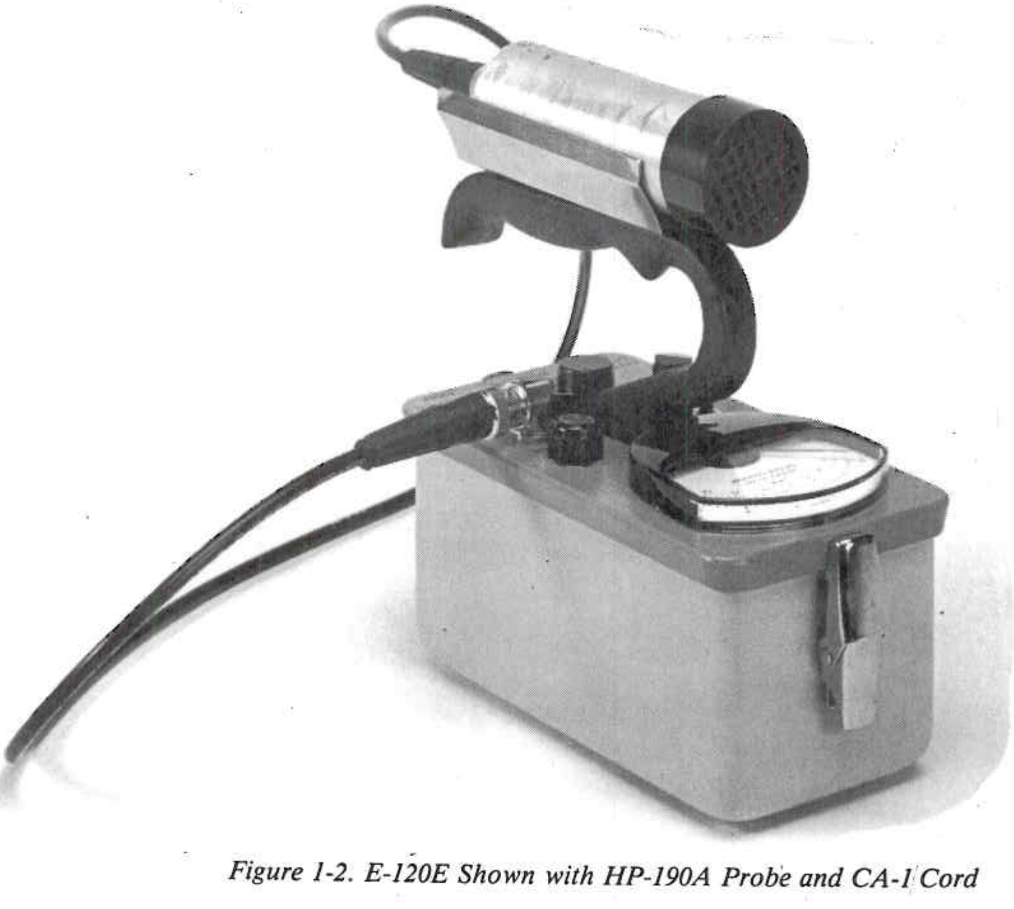

Figure 1-2. E-120E Shown with HP-190A Probe and CA-1 Cord

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The Models E-120 and E-120E are small, lightweight geiger counters for the detection and measurement of gamma (also beta with E-120E) radiation. The E-120 is typically used with external hand probe Model HP-270 and the E-120E is typically used with external hand probe Model HP-190A. The models are identical except for the detector and meter face.

Two "D" size batteries power the instrument, and special circuitry is incorporated to conserve battery life. The battery condition may be checked by a front panel control. The radiation intensity is read out on a large, easily read meter with a linear scale. Three switch-selected ranges give full scale sensitivities of 0.5, 5, and 50 mR/h (^{137}Cs) for the E-120 and 500, 5k and 50k counts per minute (cpm) for the E-120E. The response time of the meter is continuously adjustable, and the reading may be brought to zero at any time by the reset control.

A phone output is provided for the use of earphones, an Eberline Model SK-1 speaker, or for counting events with a scaler.

B. SPECIFICATIONS

The specifications listed are appropriate for the E-120/E-120E when used with the probe and cord listed.

1. Detector

	E-120 with Model HP-270 Probe	E-120E with Model HP-190A Probe
a. Geiger-Mueller Tube	30 mg/cm^2 halogen quenched	Halogen quenched, thin window, 1.4 - 2.0 mg/cm^2
b. Sensitivity (^{137}Cs)	Approximately 1200 cpm per mR/h	Approximately 2500 cpm per mR/h
c. Energy Response	See Figure 1-3	N/A
d. Dead Time	Approximately 100 μs	Approximately 200 μs
e. Housing	Impact resistant plastic	Protective screen end cap
f. Environment	Weatherproof	Weatherproof
g. Cable	CA-1-36 (STANDARD)	CA-1-36 (STANDARD)
h. 2π Beta Efficiency with end cap removed	N/A	^{90}Sr-^{90}Y: Approximately 35 percent ^{99}Tc: Approximately 25 percent ^{14}C: Approximately 10 percent

2. Indicator

a. Visual

(1) Scale length: 2.37 inches (6 cm)

(2) Scale Marking:
E-120: Dual scales, 0 to 5 mR/h with 25 increments and 0-6k cpm with 30 increments.
E-120E: 0 to 5k cpm with 25 increments.

(3) Range: Switch controlled multipliers of X0.1, X1 and X10, yielding 0.5, 5, or 50 mR/h (600, 6k or 60k cpm) for E-120, and 500, 5k, or 50k cpm for E-120E.

(4) Response Time: Continuously adjustable by *RESPONSE* control from 2 seconds to 10 seconds, measured to 90 percent of final reading.

(5) Linearity: Within ±5 percent of full scale, typically ±2 percent of F.S.

(6) Saturation: E-120 meter will remain pegged in

^{137}Cs gamma fields up to at least 5 R/h when using a HP-270 probe. E-120E not specified.

(7) Battery Dependence: Calibration shifts less than 10 percent with battery voltage change from 3 to 2 V (new batteries to end point).

b. Aural:

(1) Connector: Miniature audio style.

(2) Signal: One pulse for each event counted. Negative 2.5 V capacitively coupled.

3. Power

a. Battery Complement: Two each "D" size batteries of any type with voltage between 1.0 and 1.6 V per battery.

b. Battery Life: Depends on battery type, age, and temperature. Nominal life with new batteries near room temperature is:

Type	Life
C-Zn	300 hours
Alkaline	500 hours
Ni-Cd (Single Charge)	200 hours

4. Environmental

a. Temperature: The instrument is operational from -40 °F to +140 °F (-40 °C to +60 °C) with a typical temperature coefficient of -0.15 percent per °F (-0.27 percent per °C). Maximum temperature coefficient -0.25 percent per °F (-0.45 percent per °C).

The battery type used limits the low temperature performance because of terminal voltage decrease and internal impedance increase. For prolonged operation at low temperatures, the following criteria are suggested:

Battery Type	Usable to
C-Zn	0 °F (-18 °C)
Alkaline	-40 °F (-40 °C)
Ni-Cd	-40 °F (-40 °C)

5. Mechanical

a. Size
Height: 6 ½ inches (16.5 cm)
Length: 6 ¾ inches (17.1 cm)
Width: 3 ⅜ inches (8.6 cm)

b. Weight: With batteries: 3 pounds including probe (1.4 kg).

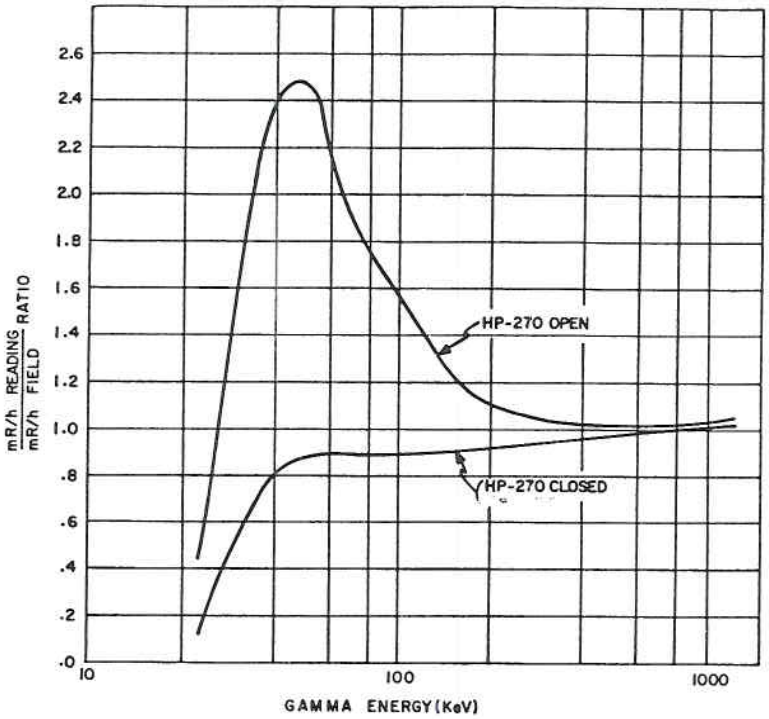

Figure 1-3. Typical Energy Response of E-120 with HP-270 Probe (10434-B42O1)

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. External (See Figure 2-1)

a. Switch: Five position rotary switch that turns instrument *OFF,* checks battery *(BATT)* condition and selects scale multipliers of X0.1, X1, X10. This number must be multiplied by the meter reading to obtain the proper field intensity.

b. *RESPONSE:* Controls response time of meter to the most desirable compromise between speed and fluctuation for the particular usage.

c. *RESET:* Discharges integrating capacitor, bringing meter reading to zero rapidly.

d. *PHONE:* Pulse output for use with earphone, speaker, or external scaler. Mating connector is Switchcraft #5501F.

e. Detector Connector: Connection to Hand Probe. BNC series coaxial.

2. Internal (See Figure 2-1)

a. Calibration Controls: One control for each range which individually calibrates that range to agree with the radiation field.

B. PREPARATION FOR USE

1. Inspection

The instrument should be checked for physical damage.

2. Connections

Connect the probe cable to the detector connector.

C. USING THE INSTRUMENT

1. Starting

Turn the switch to the *BATT* check position. The meter should indicate within the *BATT OK* area.

2. Operation Check

Place a check source in a repeatable position adjacent to the detector and move the switch to a range that gives an upscale reading. Note that the reading is sensitive to the position of the source. The reading may be recorded for future reference.

Push the *RESET* button and the reading should drop to zero rapidly, then climb back to source reading when the *RESET* is released. The *RESPONSE* may be adjusted to get the most desirable compromise between speed of response and meter fluctuation.

3. Interpretation of Indications

The meter reading must be multiplied by the scale factor to obtain the proper number. The fluctuation of the meter is normal and is caused by the random nature of radioactive decay.

On the E-120, either the mR/h or the cpm scale may be read. Prime calibration at the factory is mR/h using a ^{137}Cs source. The relation between the two scales is the average for the Geiger-Mueller tube used in the E-120 in a ^{137}Cs field. Thus, the cpm scale will be close to true frequency and may be used without recalibration. However, if cpm is to be used, and maximum accuracy is desired, the instrument should be recalibrated using a frequency standard.

The E-120E is calibrated to read true pulse frequency.

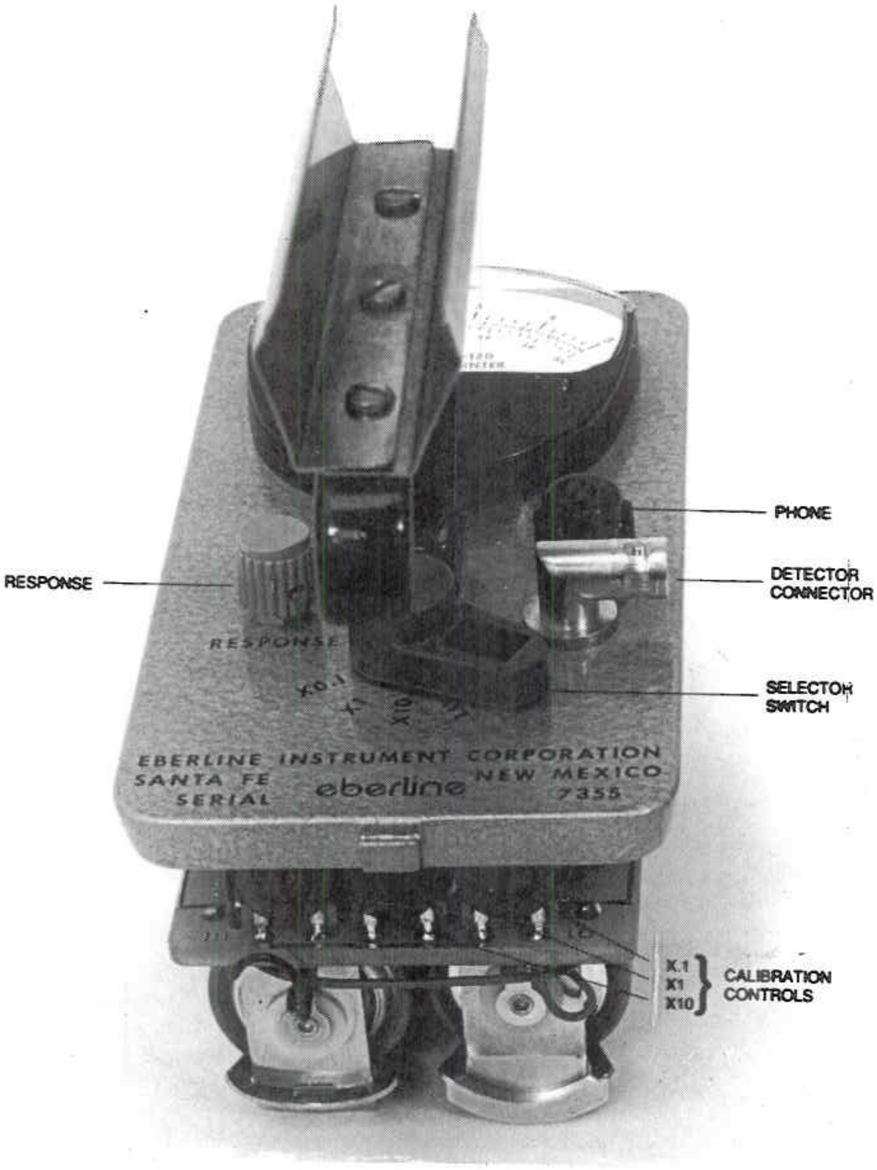

Figure 2-1. Internal and External Controls

SECTION III
THEORY OF OPERATION

A. GENERAL (See Figure 3-1)

The high voltage supply develops + 900 V, which is applied to the geiger tube, giving it the proper operating voltage. When radiation reacts in the geiger tube, negative pulses are generated. These pulses are coupled into the amplifier where they are amplified. They are then coupled to the trigger circuit where they are converted to standard size pulses of power. These standard pulses are applied to the meter driver which converts them to standard pulses of current, averages this current and drives the meter. Thus the meter deflection is proportional to the average rate of radiation at the geiger tube.

B. FUNCTIONAL THEORY (See Figures 3-1 and 6-1)

1. High Voltage Supply

The oscillator transistor Q1 drives T1 primary and gets its feedback from T1's red-orange winding. The voltage is stepped up by T1's secondary, rectified, filtered, and applied to V1. V1 regulates at 900 V. The current through V1 is sensed by Q2, amplified and used to control the current through Q3. The current through Q3 controls the bias level of the oscillator Q1. This tends to hold the current through V1 to a constant value, regardless of battery voltage. The result of this is that power is not wasted with new batteries and will still function with lower voltage batteries. This greatly extends battery life.

2. Amplifier

Q4 amplifies and inverts the negative input pulses from the detector. It is biased just into cut-off so its output is near 0 V. A pulse turns it on and the resulting positive output starts the trigger circuit.

3. Trigger

Integrated circuit A1 is connected to operate as a monostable multivibrator whose pulse width is controlled by the RC time constant between its pins 7 and 3. This time constant is established by the setting of S1B (scale selection) which selects a particular R and C. The calibration controls form the R for each scale, making the pulse width continuously adjustable for calibration.

When the trigger is initiated by the pulse from Q4, the output at pin 6 goes positive and holds until the predetermined time (RC) elapses.

4. Meter Driver

The driver Q5 is normally off so no current flows through M1. When the trigger is on, Q5 is turned on and current flows. The amount of current is determined by the voltage on the base of Q5 and the value of R15. The length of time that current flows is determined by the pulse width of the trigger. This (current times time) forms a certain charge which is transferred to C9 for each event counted. C9 discharges through M1, yielding a certain average current dependent on the rate of input pulses. Changing the pulse width of the trigger (i.e., changing scales or calibration pot setting) changes the average current for a given input pulse rate. This allows the meter to be calibrated to read in mR/H (or cpm) at the detector.

The response time of M1 is controlled by the RC time constant of C9 and R16, the response control. With R16 set to low resistance the time constant is fast, and at high resistance it is slow.

5. Phone Driver

Q6 amplifies and inverts the output pulse from the trigger, yielding a large amplitude negative going pulse which is capacitively coupled to the *PHONE* connector.

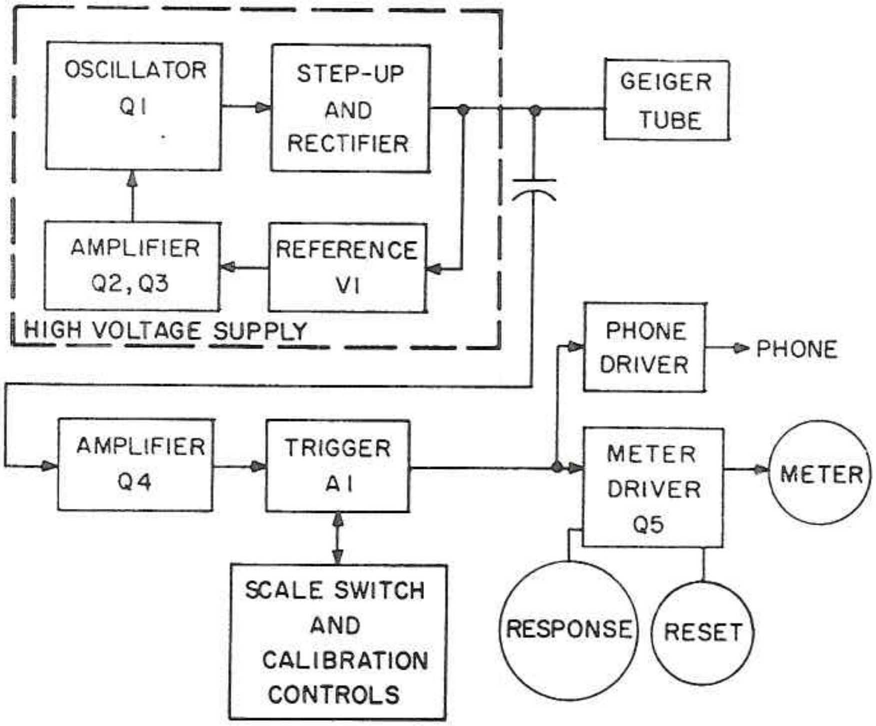

Figure 3-1. System Block Diagram

SECTION IV
MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. Batteries

The batteries are secured in holders on the etched board. Pull the batteries from the holders. Replace by sliding the batteries into holders, making certain they are centered and of the correct polarity. The red terminal cover indicates positive polarity at that end. Care should be exercised when changing batteries because of the sharp edges on the battery holders.

2. Etched Board

The etched board and cover may be separated for troubleshooting. Proceed as follows:

a. Remove the batteries to prevent electrical damage during disassembly.

b. Remove the knob and mounting nut from the scale switch.

c. Remove the two nuts from the meter studs.

d. Separate the board and cover without putting undue stress on the wires.

e. For troubleshooting, place jumpers from the meter studs to corresponding points on the board and replace the batteries.

f. Reassemble in reverse order of disassembly.

B. PREVENTIVE MAINTENANCE

1. Keep the instrument clean and dry.

2. Replace the batteries when their check reading is below the acceptable level.

3. Remove the batteries if the instrument is to be inactive for six months or more.

C. CALIBRATION

For maximum accuracy, the instrument should be calibrated under the same conditions as it will be used. Refer to Section I.B. for effects of gamma energy, battery voltage, and temperature. Proceed as follows:

1. Each range is individually calibrated by a calibration control *(X.1, X1, X10)*. Repeat the procedure below for each range.

a. Position the instrument on a calibration range so the detector center is in a field corresponding to near three-quarter scale meter reading.

b. Expose the gamma source and note the instrument reading. Adjust the calibration control for the range selected until the meter indication agrees with the field.

2. Calibrations in Counts per Minute

If counts per minute is to be read instead of mR/h, then calibration should be to true frequency. Capacitively couple a pulse generator into the probe connector using a capacitor with a 1 kV or higher voltage rating. The pulse generator must have a negative pulse approximately 350 mV amplitude and frequency covering the instrument range.

Adjust the pulse generator frequency to correspond with approximtely three-quarter scale meter reading and adjust the calibration control for the range selected until the meter agrees with the frequency. Repeat for each range *(X.1, X1, X10)*.

D. TROUBLESHOOTING

Typical voltages and waveforms are given on the schematic (Figure 6-1), and component locations are shown in Figure 6-2.

Voltages are measured with a 20,000 Ω/V, or greater, voltmeter except the 900 V point. An electrostatic voltmeter or voltmeter with 1000 MΩ minimum input impedance should be used to check the 900 V; however, if one is not available a conventional meter may be used for an indication of the presence of high voltage.

SECTION V
PARTS LIST

The following table lists the electronic items incorporated in the Model E-120/E-120E and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only. There are no restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

REF DESIG	PART	DESCRIPTION	EBERLINE PART NUMBER
A1	Integrated Circuit	RTL Dual NOR Gate	ICRTC0810G
BT1, BT2	Battery	Alkaline "D" Cell	BTAK3
	Battery Holder Kit		BTBH4
C1, C9	Capacitor	330 μF, 10%, 6 V	CPTA331M3D
C2	Capacitor	0.047 μF, 10%, 100 V	CPPF473P3P
C3, C10	Capacitor	3.3 μF, 10%, 15 V	CPTA335P3H
C4	Capacitor	0.01 μF, 1.6 kV, 20%	CPCE103PXV
C5	Capacitor	0.001 μF, 3 kV, 10%	CPCE102P3Y
C6	Capacitor	0.0068 μF, 10%	CPPF682P3O
C7	Capacitor	0.068 μF, 10%, 200 V	CPPF683P3R
C8	Capacitor	0.68 μF, 10%, 35 V	CPTA684P3L
C11	Capacitor	33 μF, 10%, 10 V	CPTA330M3F
CR1, CR2	Diode	Zener, 3.9V	CRZR1N0748
CR3	Diode	1N4148	CRSI1N4148
CR4	Rectifier	VA25	CRSIVA0025
J1	Phone Jack	Male Panel Connector	COAF12
M1	Meter	0-50 μA, W/10434-B01 MR/H & CPM FACE	MTPA23
	Meter face ONLY (for E-120E)		ZP10472127
Q1	Transistor	Germanium	TRGP2N404A
Q2, Q3, Q5, Q6	Transistor	Silicone (NPN)	TRSN2N4124
Q4	Transistor	2N4126, To-92	TRSP2N4126
R1, R3	Resistor	270, 5%, 1/4 W	RECC271B22
R2	Resistor	62k, 5%, 1/4 W	RECC623B22

REF DESIG	PART	DESCRIPTION	EBERLINE PART NUMBER
R4	Resistor	330, 5%, 1/4 W	RECC331B22
R5	Resistor	22M, 5%, 1/2 W	RECC226B23
R6	Resistor	1M, 5%, 1/4 W	RECC105B22
R7	Resistor	4.7k, 5%, 1/4 W	RECC472B22
R8	Resistor	24k, 5%, 1/4 W	RECC243B22
R9	Resistor	27k, 5%, 1/4 W	RECC273B22
R10	Resistor	2.2k, 5%, 1/4 W	RECC222B22
R11	Resistor	2.7k, 5%, 1/4 W	RECC272B22
R12, R13, R14	Potentiometer	10k, 9167 (X201R103B)	PTCC103B02
R15	Resistor	220, 5%, 1/4 W	RECC221B22
R16	Potentiometer	10K, 20%, 42444 10k, 20%, linear taper, 1/4-32 x 1/4 Long FMS Non-Lock Bushing, 1/8 x 1/2 Long FMS Flatted Shaft (for set screw)	PTCC103B43
R17	Resistor	10k, 5%, 1/4 W	RECC103B22
R18	Resistor	1k, 5%, 1/4 W	RECC102B22
S1	Switch, Rotary	Scale, 10434-014	SWRO27
S2	Switch, NO	*RESET*	SWPB5
T1	Transformer	M7120	TFHV2
V1	Regulator Tube	10459-B29 GVA900	TUVR900
J2	Connector, Probe	31-222 Angle Recept	CXBN9
	Probe Cable	BNC-BNC, 36" long	CA-1-36 (STANDARD)
	Probe Cable	BNC-BNC, 60" long	CA-1-60 (OPTIONAL)

SECTION VI
DIAGRAMS

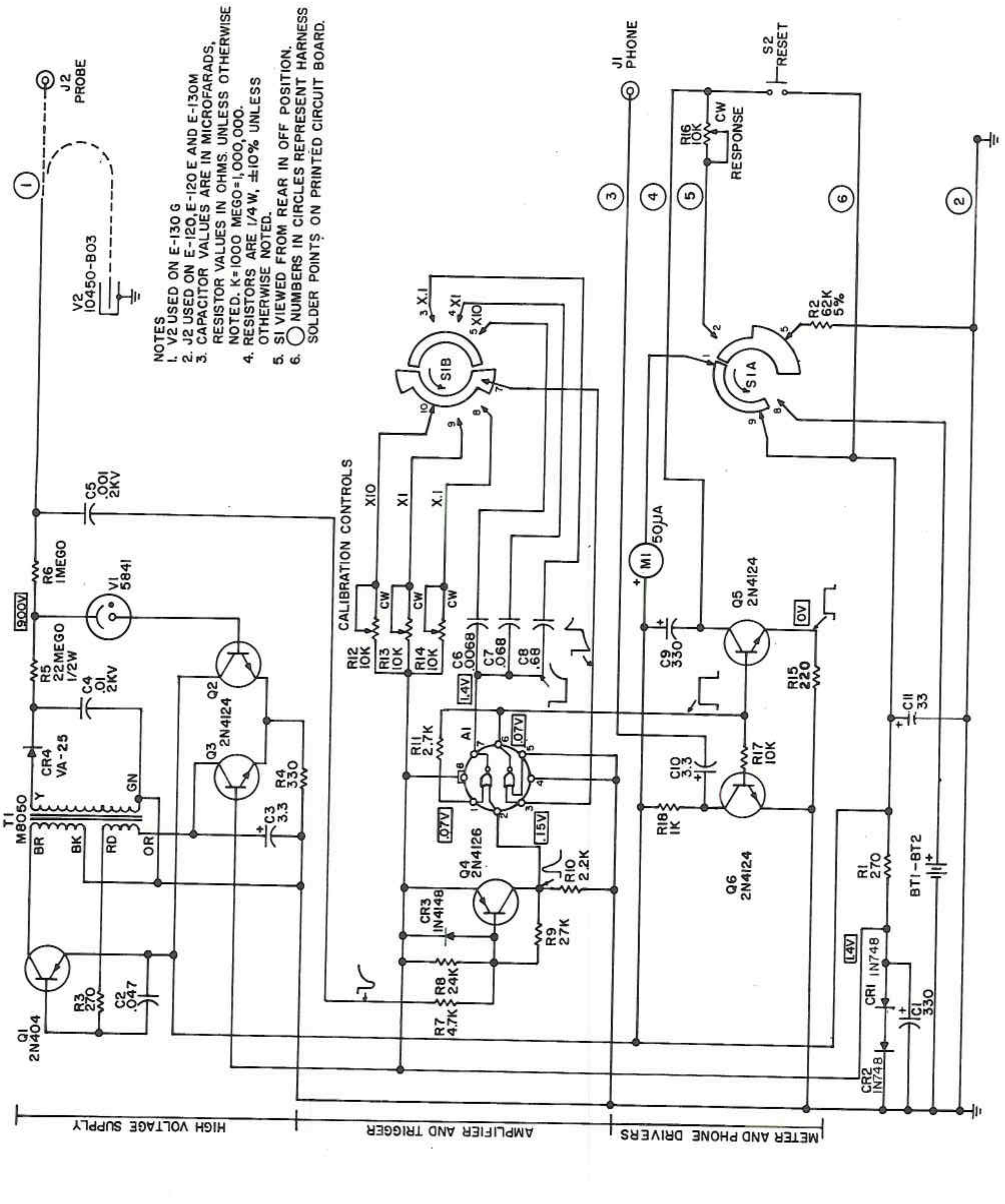

Figure 6-1. General Schematic of E-120/E-120E (10434-C07J)

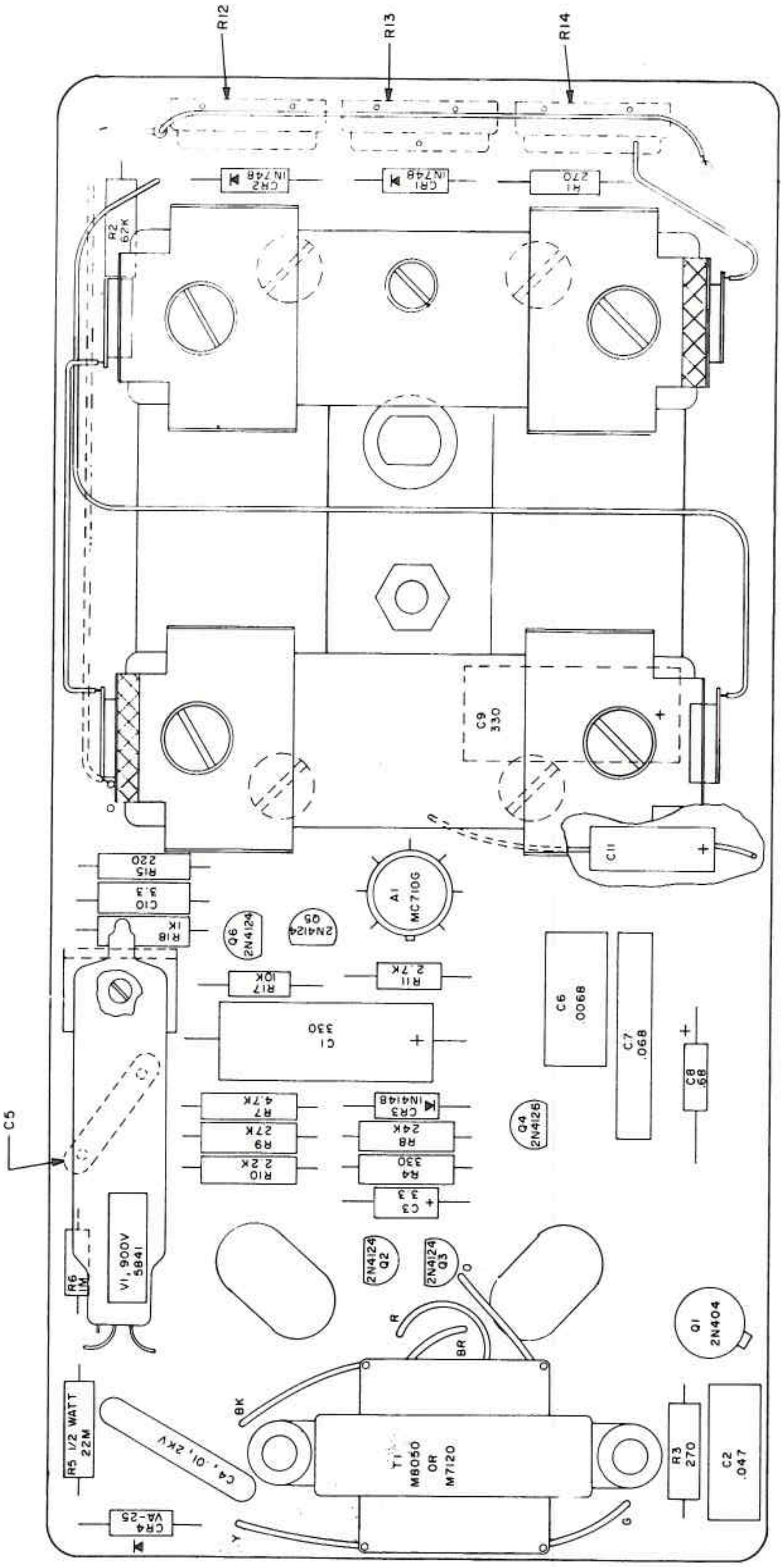

Figure 6-2. Component Layout (10434-C43B)